Space Weather Technical Forecast

Issued on Wednesday, 15 February 2023 at 12:31 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Further M-flares (R1/R2 Radio Blackouts) likely, with a slight chance of isolated X-flares (R3 Radio Blackout). CME arrival expected on Day 3 (17 Feb), G1/Minor Storms likely with chance G2/Moderate Storms.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate in the last 24 hours, with three low level M-flares, all originating from AR3213 which is no longer visible on the northwest limb. There are now eight sunspot regions on the visible disc. The most noteworthy region currently is AR3226 in the northeast, which is now a mature region with a very small delta spot. AR3213 is leaving the disc but will still present a flare risk until it is well over the limb. AR3214 is a moderate sized group, but has been fairly stable and this region is also approaching the west limb. Most other regions are either small and magnetically simple or relatively stable.
A CME eruption from near AR3220, including a small disappearing filament, is still being assessed but is likely to have an Earth directed component. At this stage the best estimate for an arrival time is during Day 3 (17 Feb).

Solar Wind / Geomagnetic Activity: There have been CME effects of varying strength through this period, with a weak arrival around 14/2200 UTC and either a strengthening or second CME around 15/0430 UTC. Wind speeds at L1, as measured by DSCOVR, were at ambient levels varying between 320-370 km/s. The density started below average, but rose above average after 14/2200UTC peaking at 29ppcc. Total IMF, Bt, was mostly weak but jumped to moderate around 15/0430 UTC, peaking at 13nT. The north-south component, Bz, varied weakly but mostly south at first, becoming moderately southward directed from 15/0430 UTC, down to -11nT. The Phi angle was positive (away from the Sun) at first, becoming variable from 15/0300 UTC. Geomagnetic activity was Quiet at first, becoming Unsettled to Active with a G1/Minor Storm interval 15/0600-0900 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at background levels. The high energy electron flux (greater than 2MeV) measured by GOES-16 started at Moderate levels, dropping to background at 14/2330 UTC. The associated 24-hour electron fluence started above the Active (1e8 integrated pfu) level but soon dropped below Active on a declining trend. The fluence at 15/0001 UTC was 4.88e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to remain Moderate, with further M-class flares. There is a slight chance of becoming High with any isolated X-flare.

Solar Wind / Geomagnetic Activity: Earth is currently experiencing CME effects, which should slowly decline during the next 24 hours or so. A recent CME is still being assessed but appears likely to be Earth directed. At present, the most likely arrival time seems to be sometime during Day 3 (17 Feb). There are no significant coronal holes in the forecast at present, however in

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addition to any CME effects, it is possible that wind speeds could reach slightly elevated levels at times on Days 3 and 4, but this is low confidence.
Geomagnetic activity is expected to be Unsettled to Active with a declining chance of further G1/Minor Storm intervals during Day 1 (15 Feb). Largely Quiet to Unsettled on Day 2 (16 Feb), before increasing to Active to G1/Minor Storm on Day 3 with a chance of G2/Moderate Storm intervals, slowly declining through Day 4 (18 Feb).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels, but with a slight chance of exceeding S1 in response to any significant flares. High energy (greater than 2 MeV) electron flux is expected to be at mostly background levels due to CME effects. The associated 24 hour fluence is expected to remain below the Active threshold (1e8 integrated pfu).

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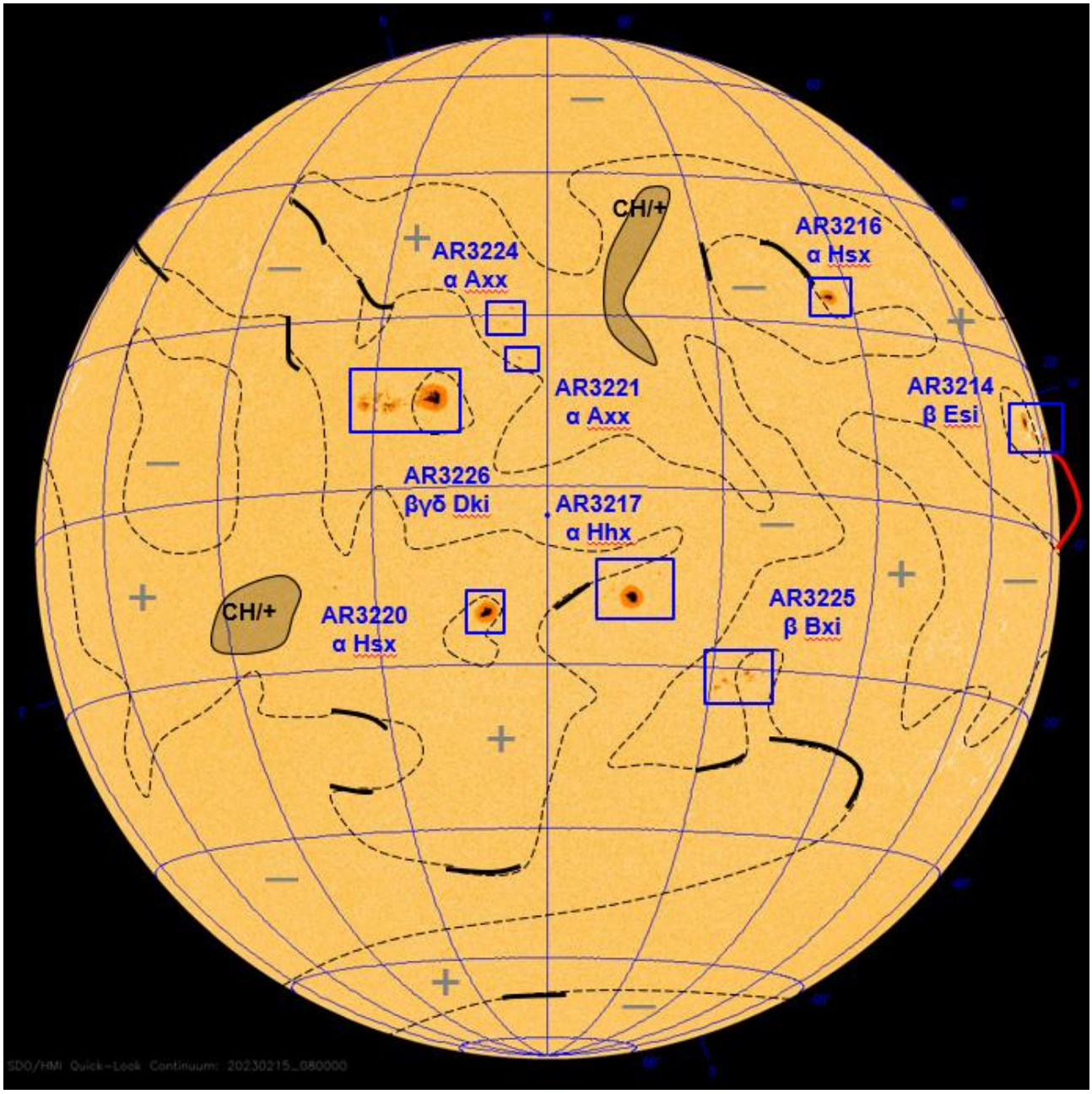
Figure 1. Solar Analysis Valid 15/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Earth is currently experiencing CME effects, which should slowly decline during the next 24 hours or so. An eruption occurred from near AR3220 early on 15th, combined with a small disappearing filament. The resulting CME is still being assessed but appears likely to be Earth directed. At present, the most likely arrival time seems to be sometime during Day 3 (17 Feb).

There are no significant coronal holes in the forecast at present, so the solar wind speed is likely to remain at largely ambient levels until the CME arrival on Day 3. Enlil is suggesting a High Speed Stream (HSS) arrival on Day 2 (16 Feb), and on the previous rotation there was a HSS on the equivalent of Day 3 (17 Feb). However, imagery suggests any remnant coronal hole is very weak and less obvious than the previous rotation, so it is unlikely to give significant wind speed increases. Also, there is another weak possible coronal hole feature near centre disc in the north, which could potentially give some small enhancement to solar winds toward the end of the period. Therefore, in addition to any CME effects, it is possible that wind speeds could reach slightly elevated levels at times on Days 3 and 4, but this is low confidence.

Geomagnetic activity is expected to be Unsettled to Active with a declining chance of further G1/Minor Storm intervals during Day 1 (15 Feb). Largely Quiet to Unsettled on Day 2, before likely increasing to Active to G1/Minor Storm on Day 3 with a chance of G2/Moderate Storm intervals, slowly declining through Day 4.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	Yes	30	5	60	30
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
15/0815	Partial	Filament / AR3220	SE	650	17/1800 UTC	Low confidence in arrival time

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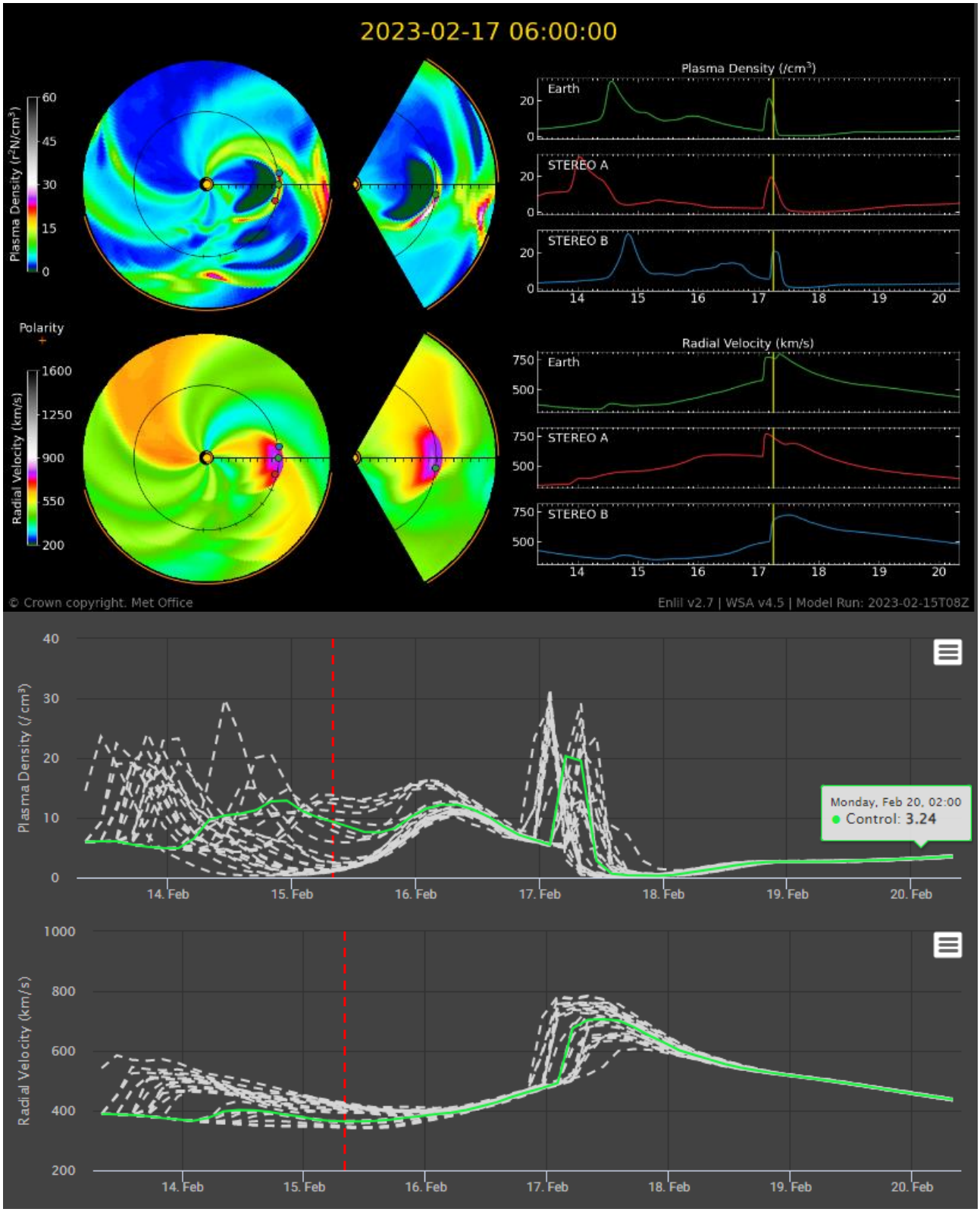
Figure 2: MOSWOC Enlil and ensemble. A slightly later CME arrival time is currently favoured on the 17th, later than shown in this Enlil run.



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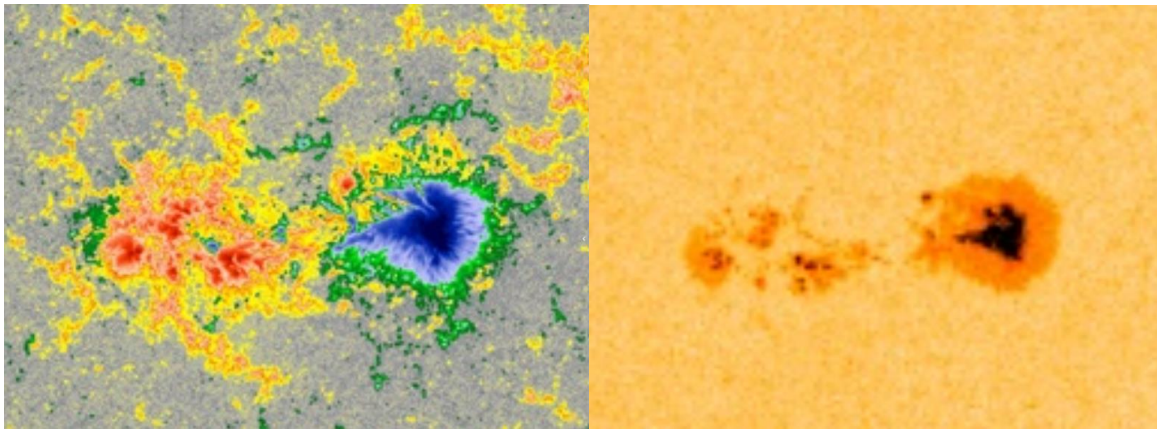
Radio Blackouts - X-Ray Flares:
Solar activity has been Moderate in the last 24 hours, with three low level M-flares, all originating from AR3213 which is no longer visible on the northwest limb.

There are now eight sunspot regions on the visible disc. The most noteworthy region currently is AR3226 (Dki/Beta-Gamma-Delta) in the northeast, which is now a mature sunspot region. A very small delta spot appears to be present in the intermediate portion. AR3213, which has a history of flaring, is leaving the disc but will still present a flare risk until it is well over the limb. AR3214 (Esi/Beta), a moderate size group, has been fairly stable and this region is also approaching the west limb. Most other regions are either small and magnetically simple or relatively stable.

Further M-class flares are likely, with a slight chance of isolated X-class flares. A slight reduction in risk is indicated as regions AR3213, and then AR3214, rotate off the west limb. However, far side seismographs and STEREO-A EUV imagery indicate that a bright area of flux could reach the east limb during the period, perhaps associated with returning region(s).

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	50	50	40	40
Very Active	R3 to R5 X Class	No	10	5	5	5

Figure 3: AR3226, showing a very small delta region in its intermediate spots.



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Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels. No notable high energy proton response has been observed from recent M-flares. Any further significant flares may increase count rates, with a slight chance of exceeding the S1 level. AR3213 is currently rotating off the disc, with AR3214 soon following. AR3217 has decayed significantly in the last couple of days and is considered unlikely to present a significant risk of a proton event in its current configuration. This means that as AR3226 rotates westward it will maintain some risk of a proton enhancement, but this perhaps lower than in recent days.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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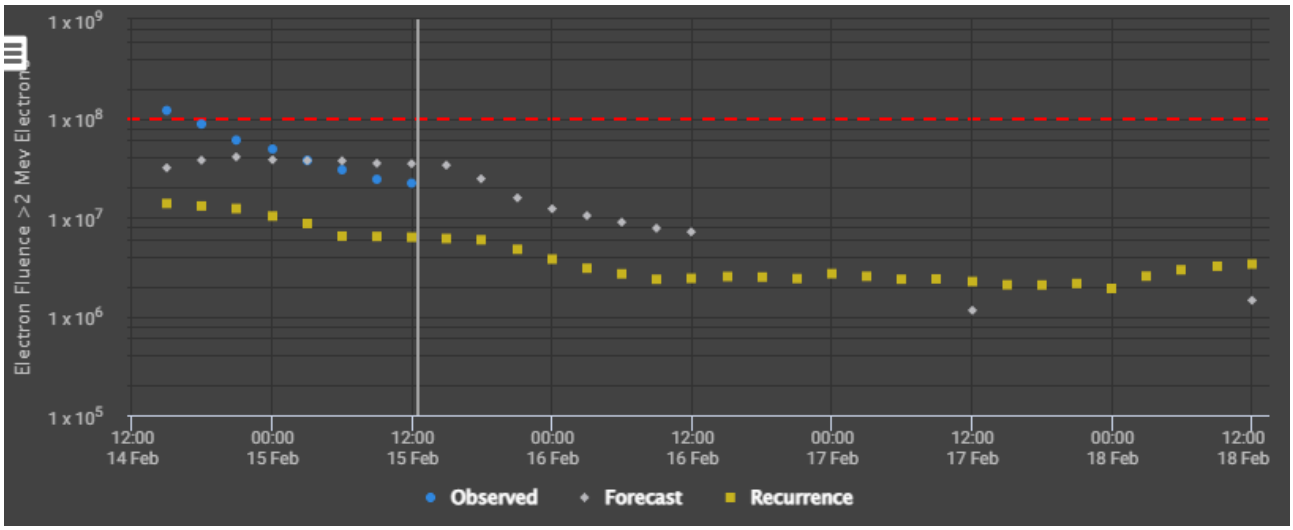
High Energy Electrons Event (≥ 2MeV):
The high energy (greater than 2 MeV) electron flux at GOES-16 started at moderate levels, but has now dropped to background due to ongoing CME effects. Whilst some flux increase is possible during Day 2 (16 Feb) after CME effects wane, a further CME is now expected on Day 3 (17 Feb), which is expected to suppress flux levels once again through to the end of the period.
The associated 24 hour fluence is now below the Active (1e8 integrated pfu) threshold on a downward trend. It is expected to stay below Active through the rest of the period. REFM is showing a below Active trend through the next three days, although it won't be taking account of CME effects.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: MOSWOC REFM showing a below Active trend for the next three days.



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